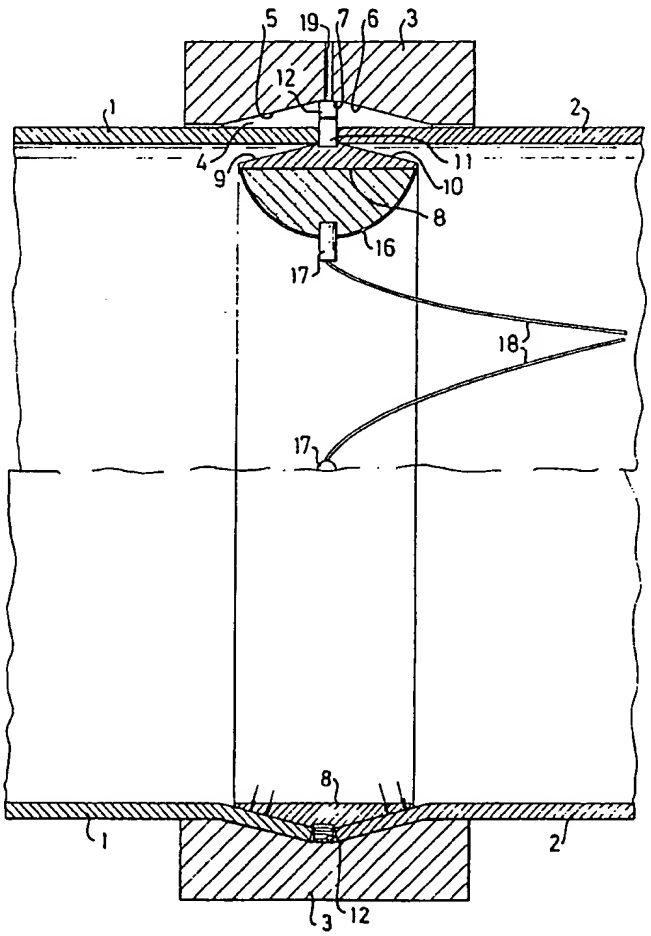
(12) UK Patent Application (19) GB (11) 2 106 817 A

(21) Application No 8226907
(22) Date of filing 21 Sep 1982
(30) Priority data
(31) 8105922
(32) 7 Oct 1981
(33) Sweden (SE)
(43) Application published 20 Apr 1983
(51) INT CL³ B23K 20/08
(52) Domestic classification B3R 17A 6 B3J 15 U1S 1884 B3J B3R
(56) Documents cited GB A 2012644 GB 1460300 GB 1430141 GB 1426680 GB 1220171 GB 0766741
(58) Field of search B3R
(71) Applicants AB Volvo, (Sweden), S-40508 Goteborg, Sweden.
(72) Inventors Bengt Persson
(74) Agents Michael Burnside and Partners, 2 Serjeants' Inn, Fleet Street, London EC4Y 1HL.

(54) **Method of joining together metal pipes by explosion and device for carrying out said method**

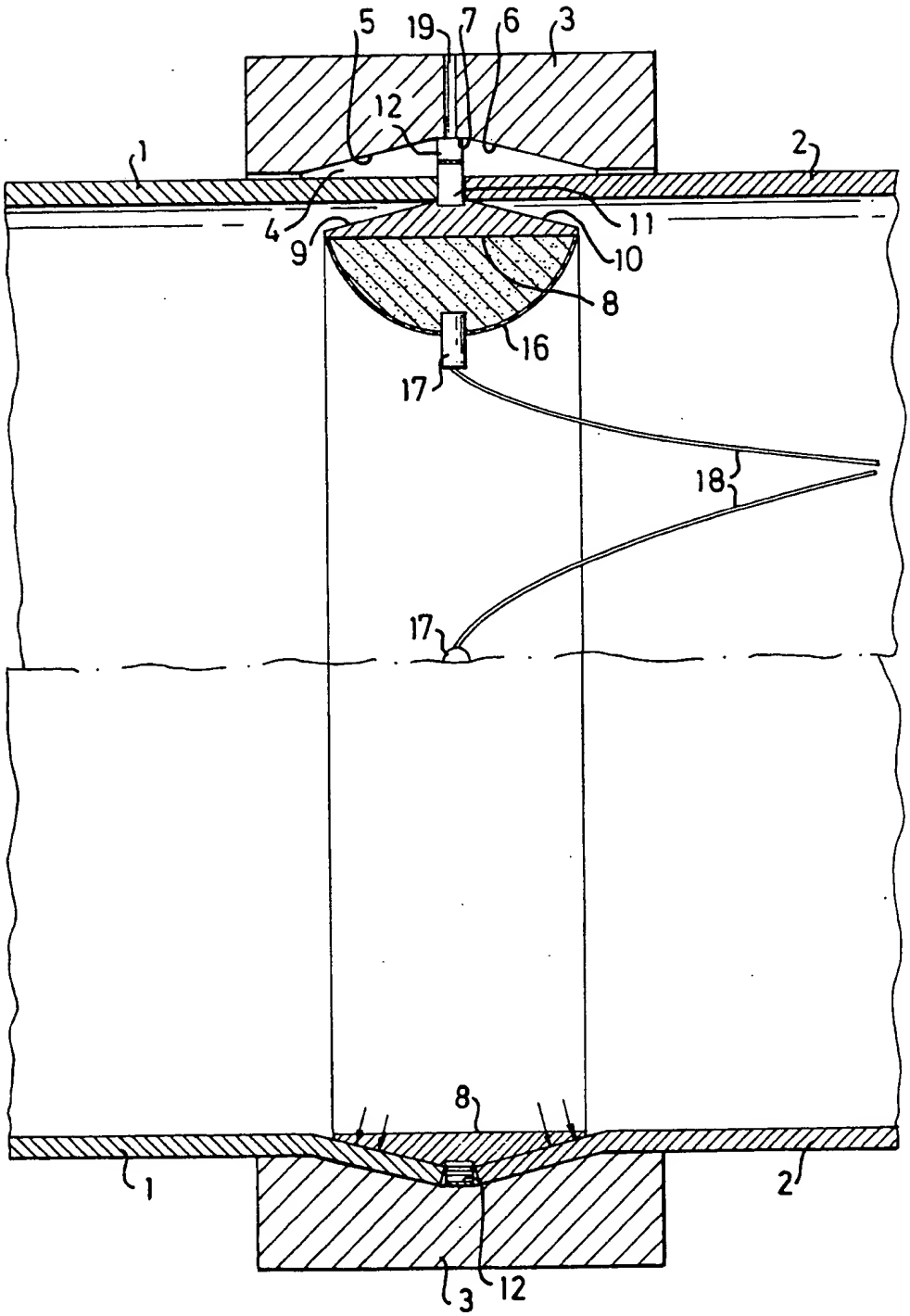
(57) Method and device for explosive joining of pipes (1, 2) in which an outer ring (3) is placed over the pipe joint and an inner ring (8) with a convex V-shaped outer surface is placed inside the pipes directly opposite the outer ring. The detonation of an explosive charge (16) inside the inner ring expands the same, deforming the pipe ends at the same time as the material in the inner ring is welded to the material in the pipe ends. A foldable spacer means 12 may be disposed between the inner and outer rings.

FIG.1



GB 2 106 817 A

FIG.1



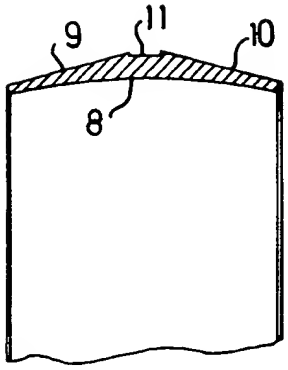
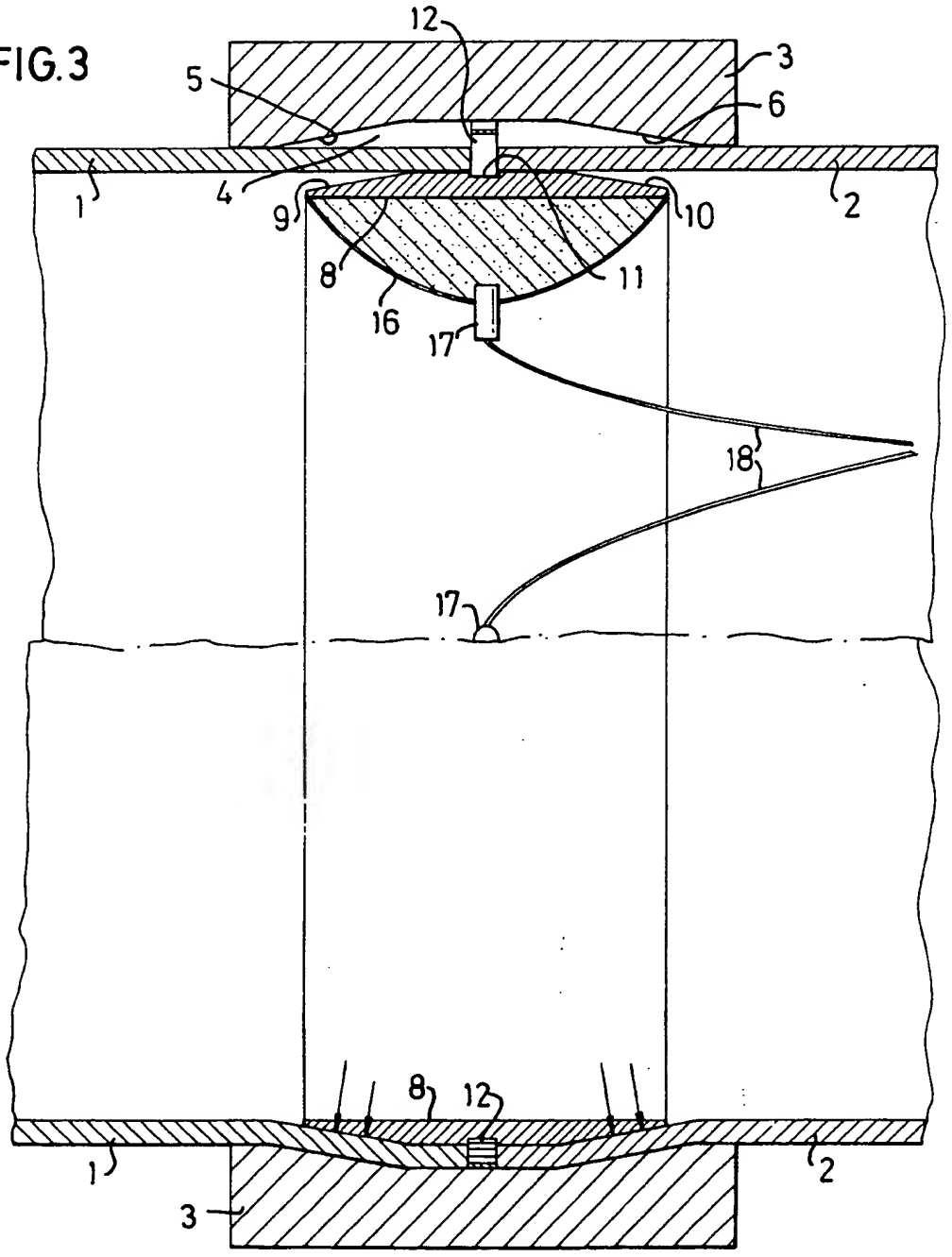


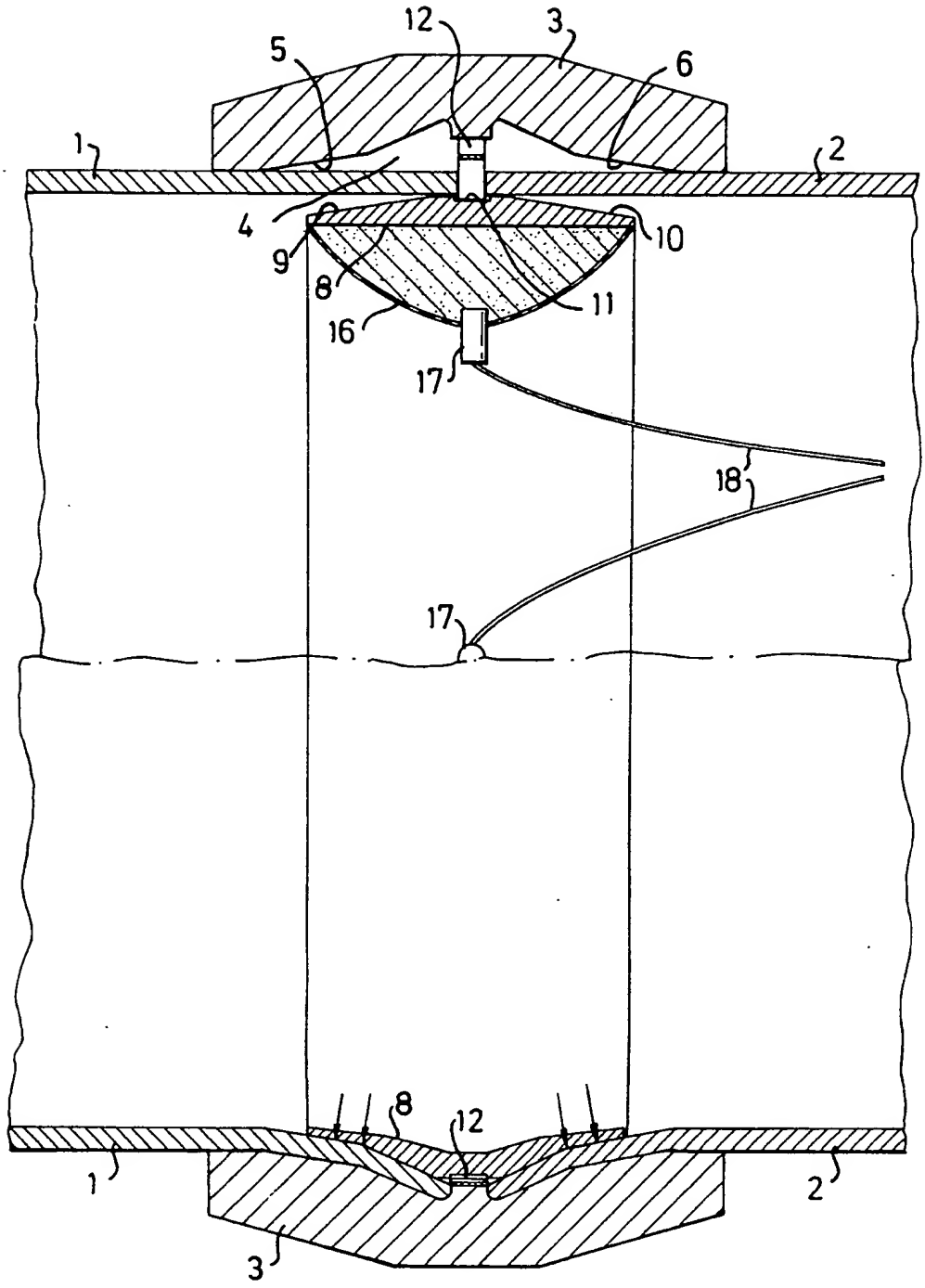
FIG.2

FIG.3



2106817

FIG. 4



2106817

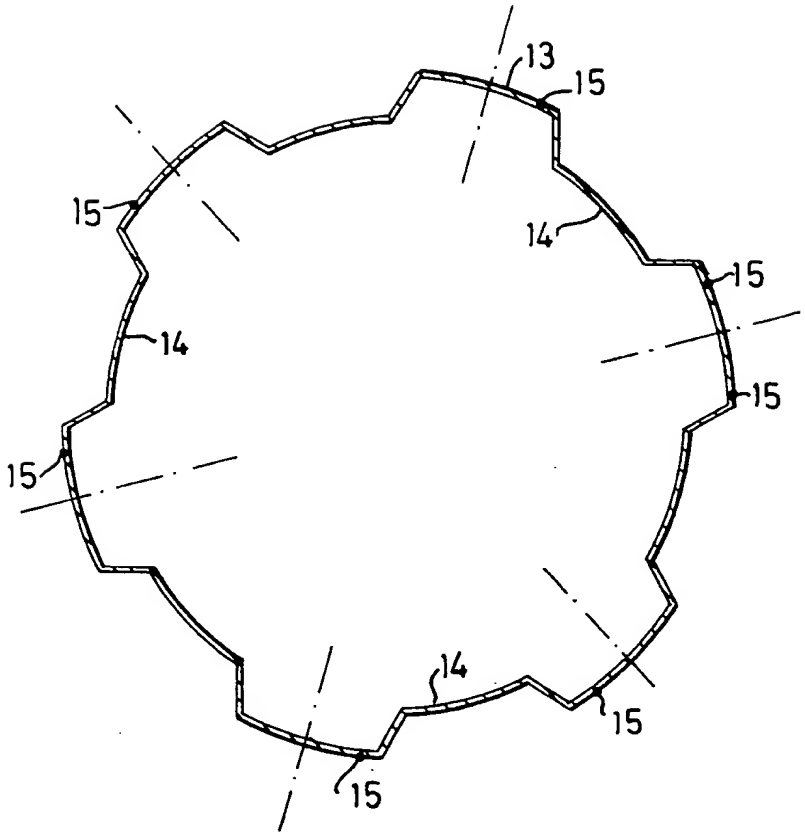


FIG. 5

SPECIFICATION

Method of joining together metal pipes by explosion and device for carrying out said method

The present invention relates to a method of joining together metal pipes by explosion, according to which the facing ends of the pipes are inserted between an outer metal ring and an inner metal ring, of which the latter has an outer profile with inclined edges, so that a wedge-shaped gap is formed between the inner ring and the interior lateral surface of each pipe end, whereafter an explosive charge is caused to detonate inside the inner ring.

Various methods of explosive joining of pipes are previously known. For example, British Patent Specification 766 741 reveals a method in which the pipe ends are inserted between an outer ring and an inner ring, and an explosive in the form of a cylinder is caused to detonate inside the latter. The pipe ends and the outer ring are thereby deformed so as to establish a shape-dependent joint between the pipes. The inner ring, which consists of soft material such as lead, is pressed into the gap between the end surfaces of the pipes to protect these end surfaces against corrosion. In using this method, there is a substantial risk that the joint will not be tight for media under high pressure and high temperature. The mechanical strength of the joint is practically entirely dependent on the deformation of the outer ring and the pipe ends, since the inner ring consists of soft material which does not increase the strength appreciably.

U.S. Patent Specification 3 290 771 reveals a method of explosive joining of thin-walled pipes provided with corrosion-protective coating. The pipe ends are inserted into annular grooves or depressions in the ends of a plastic sleeve, which surrounds the explosive charge and is in turn surrounded by a separable outer ring with a pair of annular grooves. Upon detonation, the grooves give rise to alternating valleys and ridges in the pipe ends and the sleeve, which lock the pipe ends to the plastic sleeve. After the detonation, the outer ring is split and removed. It is only possible to use this method when joining thin pipes and not for joining heavy iron pipes, e.g. in pipelines for oil or gas, and especially not for district heating pipes, which must withstand pressures up to 20 bar and temperatures up to 120°C.

Generally, the present invention is intended to provide a method of achieving, by explosion, a tight high-strength between, in the first place, heavy metal pipes such as pipes for pipelines and district heating lines. Up to now, such pipes have been welded together, which is an expensive method requiring high levels of professional skill, especially since the welding work must often be performed in inaccessible locations such as inside conduits. In many cases the welding joints must be X-rayed, which increases costs even further. Thus the invention also intends to provide a simpler, less time-consuming method requiring less equipment, for joining pipes, especially pipes located in positions which are difficult to get at.

This is achieved according to the invention by the use of an annular explosive charge, which is caused to detonate with the aid of detonator means which produces a detonation evenly distributed over the circumference of the charge, in the radial center plane of the charge, to produce oppositely directed detonation waves coming from the center plane of the charge, the explosive force of the charge being adapted so that the collision pressure between the pipe ends and the inner ring as the latter expands produces a weld between the material in the inner ring and the material in the pipe ends.

The invention is based on the idea of creating conditions similar to those in explosive welding two sheets for example, in which one sheet, after a short acceleration distance, is made to strike the other sheet, with the detonation being initiated at one end, so that the collision takes place successively towards the other end. By using, according to the invention, an inner ring with inclined edges and starting the detonation in the center, the collision zones proceed from the center in opposite directions towards the ends of the inner ring.

The joining of pipes in inaccessible spaces is particularly simple if, in a preferred application of the method according to the invention, the inner ring is first fixed to the outer ring with the aid of spacer means placed centrally between the edges of the rings. The outer ring with the attached inner ring can then be slipped over one pipe end until the pipe end edge abuts against the spacer means in the gap between the rings. After fixing the annular explosive charge in place on the inside of the inner ring, the other pipe end is inserted into the gap between the rings until its end edge abuts against the spacer means. This process requires no access at all to the joint itself; rather it is sufficient that the outer end of one of the pipes be accessible, so that a force can be applied to this end to push the pipes together. The spacer means assures that the rings will be centered precisely in relation to the pipe ends, which is essential for achieving uniform deformation and welding of the pipe ends.

The invention will be described in more detail below with reference to the embodiments shown in the accompanying drawings.

Figure 1 shows a longitudinal section through one embodiment of a coupling device for carrying out the process according to the invention, applied to a pair of pipe ends.

Figure 2 shows a modified embodiment of the inner ring in Figure 1.

Figures 3 and *4* show longitudinal sections through additional embodiments of the outer ring and the inner ring prior to and after detonation.

Figure 5 shows a side view of an embodiment of a spacer element.

In Figure 1, 1 and 2 designate the end portions of a pair of standard iron pipes 32 cm in diameter, on which a coupling device according to the invention is mounted. It comprises an outer iron ring 3 of greater thickness than the thickness of the pipes and consequently greater strength in the radial direction than the pipes. The ring 3 is made with an inner peripheral groove 4 which is essentially V-shaped with edges 5, 6 inclined towards each other on either

side of a narrow flat bottom surface 7. As can be seen from the figure, the ends of the pipes 1, 2 extend as far as the edges of the bottom surface 7.

Inside the pipe in the center of the groove 7, there is an inner iron ring 8, the width of which is approximately equal to the width of the groove 4. Its top side is made with inclined surfaces 9, 10 with the same incline as the edges 5, 6 of the groove. The surfaces 9, 10 are separated by a shallow groove 11 with a flat bottom, the width of which is equal to the width of the bottom surface 7.

The ring 3 and the ring 8 are fixed to each other with the aid of a spacer means, which can be formed of a wave-shaped steel band 12, which is shown in more detail in Figure 5. The band 12 has alternating portions 13 and 14, which in the position of the rings shown in Figure 2 are spot-welded to the bottom of the groove 4 and are snapped into the groove 11 of the ring 8. The band 12 thus has an elasticity which permits a spring movement corresponding to the depth of the groove 11. In Figure 5, 15 indicates the welding points to the groove 4. Alternatively, the band 12 can be divided into a number, e.g. six or evenly distributed short segments, as indicated between the dash-dot lines in Figure 5. By using a resilient band, which snaps into the groove in the inner ring, the assembly will be simple because the existing inclined surfaces 9, 10 are used to press the band out of the way. An additional advantage of using a spacer means of the type described is that after the deformation it takes up very little space, as will be described below.

In Figure 1 the upper half shows the position and shape of the component parts prior to detonation of an explosive charge 16 (shown schematically) fixed to the inner ring 8. The explosive charge, which can consist of an annular dynamite charge enclosed in a paper jacket, is caused to detonate by means of a number of detonators 17 distributed evenly around the circumference of the charge and connected to electric wires 18 exiting through one of the pipes. Tests have shown that six detonators provide an even shock wave resulting in uniform expansion of the ring 8. After the detonation with the accomanying expansion of the ring 8, a joint is obtained with the appearance shown in the lower half of Figure 1. The pipe ends are coned outwards and clamped between the rings, which results in a joint with a tensile strength fully comparable to that of the pipe itself. Suitable proportioning of the explosive charge together with careful cleaning of the joint areas will also provide welding between the material in the inner ring and the material in the pipes in the area between the arrows in Figure 1, so as to provide a tight joint. The band 12 is easily folded together into the space between the pipe ends and thus does not disrupt the deformation process. As can be seen in Figure 1, the inner ring 8 provides a practically smooth transition between the pipe ends, so that the joint will not produce any appreciable turbulence in the flowing medium.

In the embodiment shown in Figure 1, the greatest length of the moment arm is obtained at the initial deformation of the pipes, since the inner ring 8 abuts against the pipe ends near their outer edges. Since the size of the charge is firstly dependent on the deformation work to be carried out, this arrangement minimizes the size of the charge required. Via ventillation ducts 19, which are evenly distributed around the outer ring 3 and connect the groove 4 with the surrounding atmosphere, the medium enclosed in the groove can be quicly evacuated, which further contributes to keeping the optimum size of the charge small. Furthermore, tests carried out have shown that the existence of these ventilation ducts 19 greatly affect the quality of the welding joint between the pipes and the inner ring.

The optimum shape of the groove 4 of the outer ring and the inner ring 8 can vary depending on various factors such as pipe dimension, material characteristics, welding requirements etc. Figures 2, 3 and 4 show several modified embodiments of the outer ring and the inner ring in which the same reference numerals as in Figure 1 are used for corresponding parts.

CLAIMS

1. Method of joining together metal pipes by explosion, according to which the facing ends of the pipes are inserted between an outer metal ring and an inner metal ring, of which the latter has an outer profile with inclined edges, so that a wedge-shaped gap is formed between the inner ring and the interior lateral surface of each pipe end, whereafter an explosive charge is caused to detonate inside the inner ring, characterized in that an annular explosive charge is used, which is caused to detonate with the aid of detonator means, which produce a detonation evenly distributed over the circumference of the charge, in the radial center plane of the charge, to produce oppositely directed detonation waves coming from the center plane of the charge, the explosive force of the charge being adapted so that the collision pressure between the pipe ends and the inner ring as the latter expands produces a weld between the material in the inner ring and the material in the pipe ends.

2. Method according to Claim 1, characterized in that the inner ring is first mixed to the outer ring with the aid of spacer means placed centrally between the edges of the rings, that the outer ring is thereafter slipped over one pipe end until the end edge of the pipe abuts against the spacer means in the gap between the rings, and that the other pipe end, after the annular explosive charge is fixed in place on the inside of the inner ring, is inserted into gap between the rings until its end edge abuts against the spacer means, whereafter the explosive charge is caused to detonate.

3. Method substantially as hereinbefore described with reference to the accompanying drawings.

4. Device for joining metal pipes for carrying out the method according to Claim 1, comprising firstly, an outer metal ring and an inner metal ring, between which the facing ends of the pipes can be inserted, the inner metal ring having an outer profile with inclined edges, and secondly, an explosive charge insertable into the inner ring, characterized in that

the explosive charge is annular and has detonating means arranged to produce a detonation evenly distributed over the circumference of the charge, in the radial center plane of the charge, and that the explosive force of the charge is adapted so that the collision pressure between the pipe ends and the inner ring as the latter expands produces a weld between the material in the inner ring and the material in the pipe ends.

5. Device according to Claim 4, characterized in that the outer ring and the inner ring are fixedly to each other by means of spacer means placed centrally between the inclined edges of the inner ring, and that the annular explosive charge is fixed to the inside of the inner ring.

6. Device according to Claim 5, characterized in that the spacer means are formed of resilient elements extending radially inwards from the center of the interior lateral surface of the outer ring and evenly distributed along the circumference, said elements extending into a peripheral groove in the outer lateral surface of the inner ring.

7. Device according to Claim 6, characterized in that the resilient elements are formed of one or more wave-shaped steel bands welded fast to the outer ring and snapped into the groove in the inner ring, the thickness of said elements being substantially less than their extent in the axial direction of the rings.

8. Device substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1983.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.